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Trace Elements in Existing Wetlands and Proposed Mitigation Sites in the U.S. Bureau of Reclamation's Shoshone Rehbilitation & Betterment Project, Park and Bighorn Counties, Wyoming

Pedro Ramirez Jr.
U.S. Fish and Wildlife Service

Joni Armstrong
U.S. Fish and Wildlife Service

U.S. FISH & WILDLIFE SERVICE
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TRACE ELEMENTS IN EXISTING WETLANDS AND PROPOSED MITIGATION SITES IN THE U.S. BUREAU OF RECLAMATION'S SHOSHONE REHABILITATION & BETTERMENT PROJECT, PARK AND BIGHORN COUNTIES, WYOMING

By
Pedro Ramirez, Jr. and Joni Armstrong

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ABSTRACT

The U. S. Fish and Wildlife Service (Service) conducted a baseline inventory of trace elements at proposed mitigation sites and existing wetlands within the Shoshone Project for the Great Plains Region of the U.S. Bureau of Reclamation. Mitigation proposed for wetland losses attributed to the Shoshone Rehabilitation and Betterment Project consists of wetland creation or enhancement within the project area. The quality of irrigation drainage and its effects on fish and wildlife are potential concerns with the existing project. The two sediment samples collected from a large alkali flat near Deaver Reservoir had elevated selenium concentrations (12 and 13 ug/g dry weight). The two aquatic invertebrate samples collected from Eaglenest Creek contained elevated selenium concentrations (5.3 and 10 ug/g dry weight). One of two algae samples from Eaglenest Creek contained 2.9 ug/g dry weight selenium. Dietary selenium concentrations greater than 3 ug/g can cause reproductive impairment in aquatic birds (Lemly and Smith, 1987).

INTRODUCTION

The U.S. Bureau of Reclamation's (Bureau) Shoshone Rehabilitation and Betterment Program consists of proposed modifications to existing diversion dams and lateral canals in the Shoshone Irrigation Project, Park and Bighorn counties, Wyoming The proposed modifications could result in the loss of about 400 acres high quality grassland habitat and could impact up to 565 acres of wetland habitat (U.S. Bureau of Reclamation, 1990). Mitigation proposed for these losses includes: construction of shallow water impoundments either at Eaglenest Creek or Buck Creek or at a large alkali flat near Deaver Reservoir. Existing wetland seep areas are proposed for enhancement by creating open water areas in or near the seeps

The quality of irrigation drainage and ts effects on fish and wildlife are potential concerns within the Shoshone Project. Selenium, an element required in trace quantities for animal nutrition, can cause problems for wildlife when ingested at slightly higher concentrations. Selenium is present in many sediment deposits and in arid alkaline soils typically found in the western United States. Mobilization or release of selenium from the soil can occur through irrigation and it can reach levels hazardous to fish and wildlife. Cody Shale is a source of selenium and has been linked to elevated selenium concentrations in the food chain at the Kendrick Reclamation Project in Natrona County, Wyoming. Cody Shale also occurs in the Heart Mountain and Frannie Divisions of the Shoshone Project.

Selenium concentrations in drainwater samples collected by the Bureau in April 1990 ranged from 2 to 5 ug/l (ppb)(0.002 to 0.005 mg/l or ppm). Concentrations in water above 2 to 5 ug/l selenium may bioaccumulate in the food chain and adversely affect fish and wildlife (Lemly and Smith, 1987). In addition, the Bureau collected a water sample from Eaglenest Drain that contained 30 ug/l mercury. The U.S. Environmental Protection Agency's (EPA) acute criterion for freshwater aquatic life states that concentrations are not to exceed 2.4 ug/l mercury at any one time (U. S. EPA, 1980).

The Bureau funded this baseline inventory of trace elements at proposed mitigation sites and existing wetlands within the Shoshone Project

The objectives of this study were to: (1) determine selenium and other trace element concentrations in soils or sediments, aquatic vegetation, aquatic invertebrates and fish found in existing wetlands within the Shoshone Project and in proposed mitigation sites; and (2) evaluate selenium and other trace element concentrations in subsurface drain waters previously found to contain elevated selenium and mercury concentrations

SITE DESCRIPTION

The Shoshone Project is near the city of Cody, in Park and Big Horn Counties of northwestern Wyoming (Figure 1). Buffalo Bill Reservoir (located approximately six miles upstream from Cody), stores high flows of the Shoshone River for later release to generate power and provide irrigation for the Shoshone Project. Four irrigation districts distribute water to about 93,450 acres. The irrigation project includes two diversion dams, approximately 140 miles of tunnels and canals, 564 miles of distribution laterals and 673 miles of drains. The canals and laterals include many concrete control structures. Some sections of the canals and laterals are lined or in buried pipe; but most of the system consists of unlined open channels.

The Shoshone Project provides irrigation water for croplands and pasture. Alfalfa and barley are the primary crops, however sugar beets and dry beans are also grown. Corn, oats, wheat, other hay, silage, vegetable and seed crops represent less than 3 percent of irrigable lands. The Shoshone Project includes approximately 550 farms over 40 acres in size. The average farm size is 200 acres. Soils within the Shoshone Project are highly variable, but generally consist of two major types. The northeastern project area contains primarily residual soils underlain by shale and sandstone that contain moderate to excessive amounts of soluble salts. Cody, Thermopolis and Mowry Shales are located in the Frannie and Heart Mountain Divisions. The remaining project area contains modified alluvial soils underlain by gravel deposits.

The Shoshone River and open drains within the Shoshone Project provide waterfowl habitat. Newton Lakes and Ralston and Deaver reservoirs also provide excellent waterfowl habitat. Ducks, geese, sandhill cranes, and other aquatic birds use these areas for migration and breeding habitat. Smaller wetlands provide habitat for aquatic birds where water seeps or leaks from unlined canals

The Shoshone River supports a variety of cold-water fish. Premium trout fishery waters occur in the upper reaches of the Shoshone River from Buffalo Bill Dam to Willwood Dam, and important trout fishery waters occur in the lower reaches according to the 1987 Wyoming Trout Stream Classification Map. Sport species in these reaches include rainbow trout (Oncorhynchus mykiss), cutthroat trout (O. clarkii), brown trout (Salmo trutta), mackinaw (Salvelinus namaycush), mountain whitefish (Prosopium williamsoni), yellow perch (Perca flavescens) and channel catfish (Ictalurus punctatus). Non-game species such as the longnose sucker (Catostomus), white sucker (Catostomus commersoni), mountain sucker (Catostomus platyrhynchus), northern redhorse (Moxostoma macrolepidotum), long-nose dace (Rhinichthys cataractae), green sunfish (Lepomis cyanellus), fathead minnow (Pimephalus promelas) and flathead chubs (Hybopsis gracilis) are present. Iron Creek, Alkali Creek, Bitter Creek and Eaglenest Creek are the main tributaries of the Shoshone River within the study area used by spawning trout. Deaver Reservoir also contains a quality trout and bass (Micropterus sp.) fishery.

METHODS

Service personnel collected samples from 29-31 August 1990 with assistance from Fred Wambeke of the Deaver Irrigation District (Figure 1 and Table 1). Water samples were collected from subsurface drain outlets and from the surface at all other sites. Water samples were acidified with nitric acid to a pH of approximately 2.0 and stored in polyethylene jars. Sediment samples were collected with stainless steel utensils and stored in Whirl-pak bags. Aquatic vegetation was picked by hand and stored in Whirl-pak bags. Aquatic invertebrates were collected from reservoirs with light traps similar to those described by Espinosa and Clark (1972), and from streams with a stainless steel screen and forceps. Aquatic invertebrates were stored in glass vials. Fish were collected with seines, gill nets, and minnow traps. Samples of both bottom- and surface-feeding fish were collected at Ralston and Deaver Reservoirs. Only bottom feeders (white suckers) were collected at Eaglenest Creek. All fish except minnows were wrapped individually in hexane-rinsed, aluminum foil and composited into plastic bags. Minnows were composited into Whirl-pak bags. Sediment and biota samples were refrigerated at 20° C for less than 24 hours before freezing.

Samples were submitted to Environmental Trace Substances Research Center in Columbia, Missouri, for trace residue analyses. Reference soil and water samples were submitted to evaluate laboratory quality control. Nitric-percholoric digestion was used for arsenic and selenium analyses and nitric reflux digestion for mercury analysis. The laboratory used atomic absorption spectroscopy by hydride generation to quantify arsenic and selenium residues and by cold vapor reduction to determine mercury residues. Direct inductively coupled plasma emission spectroscopy was conducted without preconcentration for a scan of other trace elements. The precision and accuracy of the laboratory analyses were confirmed with procedural blanks, duplicate analyses, test recoveries of spiked materials, and reference material analyses

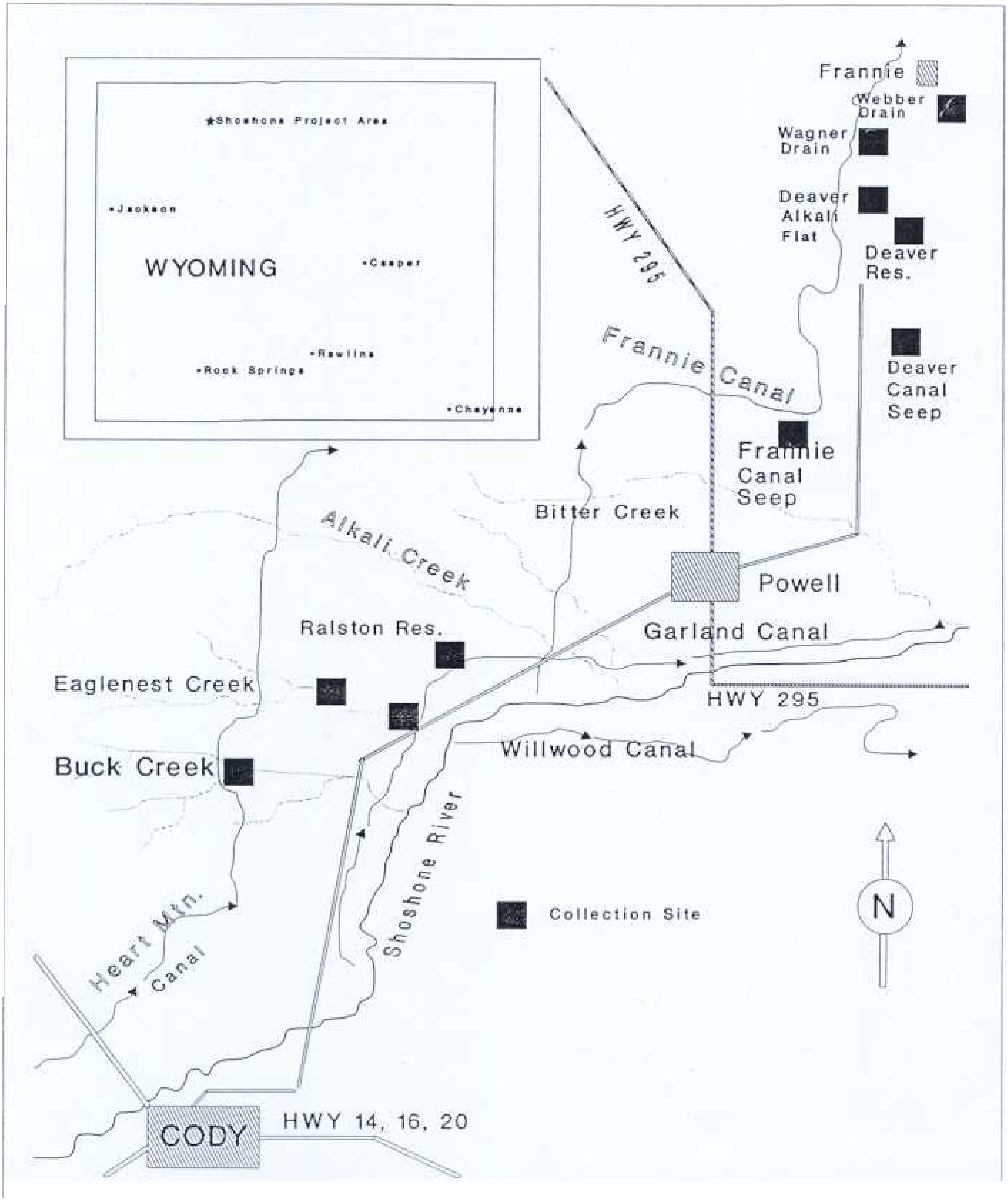

Figure 1. Collection sites for the Shoshone R & B race element study

Table 1. Number and types of samples collected at or near proposed mitigation sites for the Shoshone Rehabilitation and Betterment Project, Park and Bighorn counties, Wyoming.

Site	Water	Sediment	Matrix Aquatic Vegetation	Aquatic Invertebrates	Fish
Deaver Irrigation District					
Wagner Drain	1				
Weber Drain					
Deaver Alkali Flat		2			
Deaver Canal Seep		2			
Deaver Reservoir	1	2	2		2
Heart Mountain Irrigation District					
Eaglenest Drain	1				
Eaglenest Creek	1	2	2	2	2
Buck Creek	1	2			
Ralston Reservoir		2	2	2	2
Garland Irrigation District					
Frannie Canal Seep		2			

RESULTS

Water

All concentrations of trace elements in water except iron were below the U.S. Environmental Protection Agency's (EPA) criteria for the protection of freshwater aquatic life (Table 2). Iron concentrations in water collected from Eaglenest Creek, Eaglenest Drain and Buck Creek were above the 1 mg/l criteria established by the EPA for the protection of freshwater aquatic life (U.S. EPA, 1986). No criterion has been developed for phosphorus, but it was present in waters from Wagner Drain, Eaglenest Creek and Eaglenest Drain at concentrations known to stimulate excessive or nuisance growths of algae and other aquatic plants (>0.025 mg/l)(U.S. EPA, 1986). Selenium concentrations in water collected from the Eaglenest, Wagner and Weber drains were elevated (>0.002 mg/l). Selenium concentrations greater than 0.002 to 0.005 mg/l in water can be bioconcentrated in food chains and cause toxicity and reproductive failure in fish (Lemly and Smith, 1987).

Table 2. Trace element concentrations (mg/l) in water collected at or near proposed mitigation sites for the Shoshone Rehabilitation and Betterment Project, Park and Bighorn counties, Wyoming.

LOCATION	As	Hg	Se	Ag	Al	B	Ba	Be	Bi
WAGNER DRAIN	0.0021	<0.0003	0.021	<0.01	0.51	0.54	0.035	<0.0007	<0.04
WEBER DRAIN	0.0016	<0.0003	0.015	<0.01	0.58	0.39	0.027	<0.0007	<0.04
EAGLENEST DRAIN	0.0015	<0.0003	0.0026	<0.01	1.80	0.13	0.039	<0.0007	<0.04
EAGLENEST CREEK	0.0015	<0.0003	0.0015	<0.01	5.92	0.04	0.069	<0.0007	<0.04
DEAVER RESERVOIR	0.0004	<0.0003	0.0006	<0.01	0.25	0.066	0.029	<0.0007	<0.04
BUCK CREEK	0.0007	<0.0003	<0.0003	<0.01	3.36	0.02	0.040	<0.0007	<0.04

LOCATION	Ca	Cd	Cr	Cu	Fe	K	Li	Mg	Mn
WAGNER DRAIN	129.0	<0.003	<0.01	<0.002	0.51	1.0	0.062	68.9	0.051
WEBER DRAIN	528.0	<0.003	<0.01	<0.002	0.098	1.0	0.063	47.6	0.004
EAGLENEST DRAIN	58.3	<0.003	<0.01	<0.002	1.96	2.4	0.020	30.7	0.064
EAGLENEST CREEK	41.3	<0.003	<0.01	<0.002	5.94	2.4	0.012	20.6	0.12
DEAVER RESERVOIR	23.2	0.006	<0.01	<0.002	0.25	2.0	0.012	10.6	0.015
BUCK CREEK	28.8	<0.003	<0.01	<0.002	2.78	1.9	0.0072	7.31	0.060

LOCATION	Mo	Na	Ni	P	Pb	Sb	Si	Sn	Sr	Ti
WAGNER DRAIN	<0.006	199.0	<0.02	0.2	<0.04	0.07	5.44	<0.06	2.95	0.020
WEBER DRAIN	0.008	78.1	<0.02	<0.1	<0.04	0.05	4.22	<0.06	4.12	0.003
EAGLENEST DRAIN	<0.006	59.2	<0.02	0.2	<0.04	<0.04	7.76	<0.06	0.786	0.042
EAGLENEST CREEK	<0.006	33.9	<0.02	0.2	<0.04	<0.04	4.10	<0.06	0.452	0.17
DEAVER RESERVOIR	<0.006	24.2	<0.02	<0.1	<0.04	<0.04	3.63	<0.06	0.282	0.004
BUCK CREEK	<0.006	46.0	<0.02	<0.1	<0.04	<0.04	4.40	<0.06	0.242	0.044

LOCATION	Tl	V	Zn
WAGNER DRAIN	<0.07	0.003	<0.002
WEBER DRAIN	<0.07	0.007	<0.002
EAGLENEST DRAIN	<0.07	0.010	0.003
EAGLENEST CREEK	<0.07	0.016	0.016
DEAVER RESERVOIR	<0.07	0.005	<0.002
BUCK CREEK	<0.07	0.0094	0.016

Sediment

Selenium concentrations in sediments collected from the Deaver Alkali Flat site (Table 3) were elevated well above the 4 ug/g dry weight concentration in sediment that can be bioconcentrated in food chains and cause toxicity and reproductive failure in fish and aquatic birds (Lemly and Smith, 1987). All other trace elements were present at levels below detection or below concentrations suspected of causing adverse effects to the food chain

Aquatic Vegetation

Pondweed (Potamogeton sp.) was collected from Deaver and Ralston reservoirs and algae was collected from Eaglenest Creek. Submerged aquatic vegetation was not present at the other proposed mitigation sites. The selenium concentration in an algae sample collected from Eaglenest Creek approached the 3 ug/g dry weight dietary threshold considered adverse to aquatic birds by Lemly and Smith (1987) (Table 4). The boron concentration in pondweed collected from Deaver Reservoir approached the 300 ug/g dry weight dietary threshold considered adverse to aquatic birds (Eisler, 1990). Al other trace element concentrations were below those suspected of causing adverse effects to the food chain

Aquatic Invertebrates

Waterboatmen (Family Corixidae) and dragonfly nymphs (Family Odonata) were collected at Ralston Reservoir and Eaglenest Creek and had selenium concentrations exceeding the 3 ug/g dietary threshold suspected of causing adverse reproductive effects to aquatic birds (Table 5)(Lemly and Smith, 1987). All other trace elements were present at levels below detection or below concentrations suspected of causing adverse effects to the food chain.

Fish

Deaver and Ralston reservoirs and Eaglenest Creek were the only proposed mitigation sites inhabited by fish. White suckers and green sunfish were collected from Deaver Reservoir. White suckers and fathead minnows were collected from Ralston Reservoir. White suckers were collected from Eaglenest Creek. Fish collected from the proposed mitigation sites did not contain elevated concentrations of trace elements (Table 6)

Table 3. Trace element concentrations (ug/g dry weight) in sediments collected from proposed mitigation sites for the Shoshone Rehabilitation and Betterment Project, Park and Bighorn counties, Wyoming.

LOCATION	As	Hg	Se	Ag	Al	B	Ba	Be	Bi
BUCK CREEK	5.0	0.021	0.3	4.6	15100	<2.	136	0.81	<4.
BUCK CREEK	4.6	0.021	0.2	5.7	24300	<3.	125	1.2	<4.
DEAVER ALKALI FLAT	3.1	0.008	12.0	4.0	15400	11	147	0.60	<4.
DEAVER ALKALI FLAT	3.0	0.010	13.3	4.2	18400	12	160	0.74	<4.
DEAVER CANAL SEEP	2.8	0.020	0.83	1.0	3670	<2.	43	0.30	<4.
DEAVER CANAL SEEP	2.5	0.033	1.1	1.0	2860	2	28.4	0.28	<4.
DEAVER RESERVOIR	3.8	0.026	0.3	5.2	26600	3	170	1.0	<4.
DEAVER RESERVOIR	3.5	0.033	0.3	5.4	19900	3	178	1.1	<4.
EAGLENEST CREEK	3.8	0.010	0.2	3.0	12300	4	229	0.53	<4.
EAGLENEST CREEK	3.4	0.010	0.1	3.3	12600	5	180	0.52	<4.
FRANNIE CANAL SEEP	6.3	0.026	<0.1	5.0	9710	3	256	0.58	<4.
FRANNIE CANAL SEEP	7.1	0.023	0.2	5.0	8440	3	120	0.50	<4.
RALSTON RESERVOIR	3.7	0.025	1.1	5.4	28600	20	205	1.2	<4.
RALSTON RESERVOIR	3.5	0.025	0.75	4.7	17100	4	164	0.97	<4.

LOCATION	Ca	Cd	Cr	Cu	Fe	K	Li	Mg	Mn
BUCK CREEK	35200	0.3	25	17	17100	2600	15	10800	326
BUCK CREEK	30500	<0.3	30	21.7	21300	4290	20.6	11500	330
DEAVER ALKALI FLAT	113000	<0.3	15	12	13000	3800	21.3	11800	359
DEAVER ALKALI FLAT	121000	0.3	17	12	13800	4730	23.9	12300	382
DEAVER CANAL SEEP	8140	0.3	7.5	4.4	5150	1000	4.4	3560	126
DEAVER CANAL SEEP	8910	0.5	5.2	5.1	5140	640	4.2	3650	128
DEAVER RESERVOIR	15700	<0.3	20	20.3	19500	3200	16	9290	237
DEAVER RESERVOIR	15400	<0.3	23	21.7	20000	3600	19	9410	220
EAGLENEST CREEK	31200	0.4	19	8.3	11500	2400	9.7	7520	286
EAGLENEST CREEK	33200	<0.3	13	8.4	11900	2100	10	8090	283
FRANNIE CANAL SEEP	27300	<0.3	12	6.4	18300	2200	10	4010	570
FRANNIE CANAL SEEP	34900	0.4	11	6.5	19100	1600	10	4190	1020
RALSTON RESERVOIR	43100	0.4	13	18	19700	5210	22.4	11200	313
RALSTON RESERVOIR	41700	0.4	21	17	17100	3400	17	9890	310

Table 3. (Continued)

LOCATION	Mo	Na	Ni	P	Pb	Sb	Si	Sn	Sr	Ti
BUCK CREEK	<0.7	1110	22	630	16	9	4160	<6.	114	33.9
BUCK CREEK	<0.8	1710	25	640	20	8	4860	<6.	138	28.9
DEAVER ALKALI FLAT	<0.7	1490	10	690	14	8	3760	<6.	757	49.5
DEAVER ALKALI FLAT	<0.7	1750	11	710	10	9	3610	<6.	809	56.5
DEAVER CANAL SEEP	<0.7	130	8.9	400	6	4	965	<6.	23.5	39.1
DEAVER CANAL SEEP	<0.6	86	7.5	410	7	4	917	<6.	23.7	32.0
DEAVER RESERVOIR	<0.8	330	23	650	15	5	4690	<6.	87.8	43.4
DEAVER RESERVOIR	<0.8	340	22	640	21	7	3530	<6.	89.8	59.3
EAGLENEST CREEK	1.0	412	21	510	10	8	1980	<6.	77.4	158.0
EAGLENEST CREEK	<0.7	200	14	520	10	7	1420	<6.	79.1	281.0
FRANNIE CANAL SEEP	1.0	943	8.2	380	15	<4.	2420	<6.	206	49.4
FRANNIE CANAL SEEP	1.0	1000	8.6	430	14	<4.	2270	<6.	226	36.2
RALSTON RESERVOIR	<0.8	515	21	710	21	8	2390	<7.	227	387.0
RALSTON RESERVOIR	<0.8	401	20	700	18	8	3930	<6.	211	55.0

LOCATION	Tl	V	Zn
BUCK CREEK	<7.	20	54.7
BUCK CREEK	<7.	26	67.1
DEAVER ALKALI FLAT	<7.	28	47.7
DEAVER ALKALI FLAT	<7.	34	50.2
DEAVER CANAL SEEP	<7.	11	26.2
DEAVER CANAL SEEP	<7.	9.9	26.1
DEAVER RESERVOIR	<7.	27	68
DEAVER RESERVOIR	<7.	29	70.1
EAGLENEST CREEK	<7.	25	28.3
EAGLENEST CREEK	<7.	25	30.6
FRANNIE CANAL SEEP	<7.	23	32.5
FRANNIE CANAL SEEP	<7.	18	37.0
RALSTON RESERVOIR	<7.	46.3	64.6
RALSTON RESERVOIR	<7.	28	59.2

Table 4. Trace element concentrations (ug/g dry weight) in aquatic vegetation collected from proposed mitigation sites for the Shoshone Rehabilitation and Betterment Project, Park and Bighorn counties, Wyoming.

LOCATION	% MOIST	As	Hg	Se	Ag	Al	B	Ba
EAGLENEST CREEK	81.6	1.6	0.020	1.5	2.0	4710	110	58.7
EAGLENEST CREEK	87.3	1.7	0.036	2.9	1	3950	180	61.7
DEAVER RESERVOIR	91.1	1.5	0.01	1.0	<1.	1560	297	64.3
DEAVER RESERVOIR	90.9	2.1	0.01	1.1	1	2870	180	68.6
RALSTON RESERVOIR	85.5	2.2	0.02	1.4	1	3340	22	177.0
RALSTON RESERVOIR	87.0	1.9	0.075	1.4	1	4000	16	161.0

LOCATION	Be	Bi	Ca	Cd	Cr	Cu	Fe	K	Li
EAGLENEST CREEK	0.1	<4.	11300	<0.2	21	10	5210	11000	3.8
EAGLENEST CREEK	0.2	<4.	11800	0.3	14	21.5	4790	19200	3.1
DEAVER RESERVOIR	0.07	<4.	17900	<0.2	2	8.1	2230	14200	2.0
DEAVER RESERVOIR	0.09	<4.	18900	0.3	6.2	10	3180	12200	3.1
RALSTON RESERVOIR	0.08	<4.	73900	<0.2	6.5	7.9	2470	7730	3.3
RALSTON RESERVOIR	0.1	<4.	67800	<0.2	7.3	7.2	3160	8020	4.0

LOCATION	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Si	Sn
EAGLENEST CREEK	4070	534	<1.	576	14.0	1700	<4.	6	1100	<9.
EAGLENEST CREEK	4590	792	<1.	947	11.0	2630	<4.	6	1350	<9.
DEAVER RESERVOIR	3570	463	<1.	4360	3.0	2310	<4.	5	1450	<9.
DEAVER RESERVOIR	4260	657	<1.	5160	7.3	2510	5	5	1390	<9.
RALSTON RESERVOIR	7180	429	<1.	3400	4.0	1900	6	8	1240	<9.
RALSTON RESERVOIR	6380	494	<1.	3280	6.7	2000	7	8	1500	<9.

LOCATION	Sr	Ti	Tl	V	Zn
EAGLENEST CREEK	74.8	145	<4.	12.0	20
EAGLENEST CREEK	108	149	<4.	11.0	20
DEAVER RESERVOIR	185	23.5	<4.	4.6	14
DEAVER RESERVOIR	180	18	<4.	6.8	23
RALSTON RESERVOIR	640	15	<4.	8.2	21
RALSTON RESERVOIR	545	22	<4.	8.3	34

Table 5. Trace element concentrations in aquatic invertebrates (ug/g dry weight) collected from proposed mitigation sites for the Shoshone Rehabilitation and Betterment Project, Park and Bighorn counties, Wyoming.

LOCATION	% MOIST	As	Hg	Se	Ag	Al	B	Ba
EAGLENEST CREEK	76.8	1.0	0.12	10.0	<1.	2130	6	27.3
EAGLENEST CREEK	77.4	0.57	0.12	5.3	<1.	1920	<2.	34.3
RALSTON RESERVOIR	78.6	0.3	0.21	3.7	<1.	374	<2.	5.21
RALSTON RESERVOIR	80.5	0.3	0.23	3.4	<1.	398	<2.	8.35

LOCATION	Be	Bi	Ca	Cd	Cr	Cu	Fe	K	Li
EAGLENEST CREEK	<0.07	<4.	6900	0.5	3	22.7	1960	8080	1.5
EAGLENEST CREEK	<0.07	<4.	5210	0.4	3	25.8	1770	7090	1.4
RALSTON RESERVOIR	<0.07	<4.	4090	<0.2	<2	18.0	306	8430	0.3
RALSTON RESERVOIR	<0.07	<4.	4640	0.4	5	19.7	382	8720	0.3

LOCATION	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Si	Sn
EAGLENEST CREEK	2140	135	<1.0	4960	3	6650	<4.	<4.	373	<9.
EAGLENEST CREEK	1720	84	<1.0	4580	2	5880	<4.	<4.	361	<9.
RALSTON RESERVOIR	1060	18	<1.0	5180	<2.	6980	<4.	<4.	72	<9.
RALSTON RESERVOIR	1090	21	<0.9	4990	2	7620	<4.	<4.	89	<9.

LOCATION	Sr	Ti	Tl	V	Zn
EAGLENEST CREEK	32.5	81.8	<4.	5.8	123
EAGLENEST CREEK	26.0	73.4	<4.	4.8	139
RALSTON RESERVOIR	19.2	12.0	<4.	1.0	102
RALSTON RESERVOIR	23.9	15.0	<4.	1.3	104

Table 6. Trace element concentrations (ug/g dry weight) in fish (whole body) composite samples collected from proposed mitigation sites for the Shoshone Rehabilitation and Betterment Project, Park and Bighorn counties, Wyoming.

LOCATION	SPECIES	% MOIST	As	Hg	Se	Ag	Al
DEAVER RESERVOIR	WHITE SUCKER	74.2	<0.2	0.038	2.3	<0.9	275
DEAVER RESERVOIR	SUNFISH	78.5	0.3	0.26	3.8	<1.	70
EAGLENEST CREEK	WHITE SUCKER	79.4	1.3	0.058	2.1	<1.	2990
EAGLENEST CREEK	WHITE SUCKER	77.5	0.88	0.096	2.2	<1.	170
RALSTON RESERVOIR	WHITE SUCKER	77.2	0.3	0.22	3.8	<1.	160
RALSTON RESERVOIR	FATHEAD MINNOW	75.8	0.3	0.30	5.4	<1.	326

LOCATION	SPECIES	B	Ba	Be	Bi	Ca	Cd	Cr
DEAVER RESERVOIR	WHITE SUCKER	<2.	6.83	<0.07	<4.	22000	0.3	4
DEAVER RESERVOIR	SUNFISH	<2.	6.97	<0.07	<4.	48200	<0.2	3
EAGLENEST CREEK	WHITE SUCKER	<2.	35.00	<0.07	<4.	27700	0.86	10
EAGLENEST CREEK	WHITE SUCKER	<2.	12.40	<0.07	<4.	32700	<0.2	7.3
RALSTON RESERVOIR	WHITE SUCKER	<2.	5.63	<0.07	<4.	26900	0.4	4
RALSTON RESERVOIR	FATHEAD MINNOW	<2.	12.80	<0.07	<4.	27500	<0.2	5

LOCATION	SPECIES	Cu	Fe	K	Li	Mg	Mn	Mo
DEAVER RESERVOIR	WHITE SUCKER	4.8	252	11200	0.3	1140	13.0	<0.9
DEAVER RESERVOIR	SUNFISH	5.2	129	9850	0.2	1590	9.1	<1.0
EAGLENEST CREEK	WHITE SUCKER	5.7	2690	13000	2.0	3080	81.5	1.0
EAGLENEST CREEK	WHITE SUCKER	3.6	180	12900	<0.2	1520	22.0	<0.9
RALSTON RESERVOIR	WHITE SUCKER	3.4	168	9620	<0.2	1300	11.0	<1.0
RALSTON RESERVOIR	FATHEAD MINNOW	5.5	269	8260	0.3	1370	9.3	<1.0

Table 6. (Continued)

LOCATION	SPECIES	Na	Ni	P	Pb	Sb	Si	Sn	Sr
DEAVER RESERVOIR	WHITE SUCKER	2110	5	17100	<4.	4	91	<9.	62.8
DEAVER RESERVOIR	SUNFISH	3970	<2	27900	<4.	<4.	16	<9.	135
EAGLENEST CREEK	WHITE SUCKER	4130	15	19600	<5.	9	873	<9.	126
EAGLENEST CREEK	WHITE SUCKER	3900	4	24100	<4.	<4.	30	<9.	143
RALSTON RESERVOIR	WHITE SUCKER	3520	5	20500	<4.	<4.	54	<9.	118
RALSTON RESERVOIR	FATHEAD MINNOW	3240	3	20200	<4.	<4.	73	<9.	146

LOCATION	SPECIES	Ti	Tl	V	Zn
DEAVER RESERVOIR	WHITE SUCKER	5.8	<4.	0.9	42.1
DEAVER RESERVOIR	SUNFISH	1.9	<4.	0.6	99.6
EAGLENEST CREEK	WHITE SUCKER	91.6	<4.	7.0	101.0
EAGLENEST CREEK	WHITE SUCKER	5.4	<4.	0.9	147.0
RALSTON RESERVOIR	WHITE SUCKER	3.7	<4.	0.7	61.5
RALSTON RESERVOIR	FATHEAD MINNOW	7.7	<4.	1.0	142.0

RECOMMENDATIONS

Trace elements can be mobilized into aquatic food chains by agricultural irrigation return flows. Selenium in irrigation drainwater is of particular concern in the arid Western United States where many soils contain naturally high concentrations of this element. Dissolved selenium entering an aquatic ecosystem can be absorbed or ingested by organisms, it can bind or complex with particulate matter, or it can remain free in solution. Aquatic systems that accumulate selenium most efficiently are shallow, standing or slow-moving wetlands that have low flushing rates (Lemly and Smith, 1987). Closed basins receiving selenium-ladened water can, through evaporative concentration, achieve elevated selenium concentrations in the water and eventually in the food chain at levels adverse to aquatic birds and fish (See, et al., 1991)

The source or sources of selenium and its mobilization into the food chain cannot be determined based on the imited scope of this study. A geologic and hydrologic study would be required to identify potential or existing sources and to trace the transport of the selenium from the water to the sediment and biota. Additionally, the occurrence of bioaccumulation cannot be determined due to the narrow scope of this study.

Eaglenest Creek and the large alkali flat near Deaver Reservoir should not be used as mitigation sites due to elevated selenium concentrations and the potential for bioconcentration in the aquatic food chain. Selenium concentrations of 12 and 13 ug/g dry weight in the sediment from the alkali flat near Deaver Reservoir are above the 4 ug/g dry weight threshold for bioconcentration in the food chain (Lemly and Smith, 1987). If these sediments are inundated, selenium could be mobilized into the aquatic food chain at concentrations that could cause toxicity and impaired reproduction in birds Although selenium in water from Eaglenest Creek did not exceed the 0.002 mg/l threshold for bioconcentration, it did approach this level (0.0015 mg/l). Additional monitoring would verify if selenium concentrations fluctuate above 0.002 mg/l. Algae samples collected from Eaglenest Creek had selenium concentrations approaching the 3 ug/g dry weight dietary threshold for adverse effects to aquatic birds (1.5 and 2.9 ug/g dry weight). Aquatic invertebrates collected from Eaglenest Creek exceeded the 3 ug/g dry weight dietary threshold for adverse effects to aquatic birds (5.3 and 10 ug/g dry weight).

The mitigation proposals at Buck Creek and the seeps near Frannie and Deaver canals should be designed as flow-through wetlands to minimize evaporative concentration of selenium in the water. Follow-up monitoring of the aquatic food chain should be conducted after creation of the wetlands to determine if selenium is bioconcentrating

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